PROFIsafe
User manual
CRD/S3

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Inhaltsverzeichnis

1. Safety instructions

1.1 Scope of validity

This user manual applies exclusively to the following rotary encoders with PROFIsafe interface:

- CRDxx-xxxxRxxxxS3Zxx

1.2 Documentation

The following documents must be noted:

- The owner's system-specific operating instructions
- This user manual
- Data sheet number CRD 12098
- The pin assignment enclosed with the device
- Installation instruction TZY 10206 enclosed with the device

1.3 Proper use

TWK-ELEKTRONIK GmbH's rotary encoders and linear transducers are used to record rotary and linear positions, and make their measured values available as an electric output signal. As part of a system, they must be connected to the downstream electronics and must only be used for this purpose.

1.4 Commissioning

- The relevant device must only be set up and operated using this document and the documentation specified in point 1.2.
- Protect the device against mechanical damage during installation and operation.
- The device must only be commissioned and set up by a specialist electrician.
- Do not operate the device outside of the limit values which are specified in the data sheet.
- Check all electrical connections before commissioning the system.

2. General information on the CRD/S3

Due to the general spread of the PROFIBUS DP /4/ field bus, only the PROFIsafe-specific extensions are dealt with in this manual. Fundamental and more extensive information on the PROFIBUS DP field bus and PROFIsafe can be obtained from the PNO user organisation (www.profibus.com).

The CRD/S3 PROFIsafe absolute encoders are designed for direct connection to the PROFIsafe as slave subscribers in accordance with the PROFIsafe Profile for Safety Technology according to No. 3.092 or 3.192 (PNO) /1/. The encoder protocol is structured in accordance with the PROFIBUS Profile for Encoders according to No. 3.062 (PNO) /2/.

PROFIBUS-DP according to IEC61158-3 is used as the data transmission medium. Communication is equipped with a ProfiSafe interface developed by Siemens.

Prerequisites for operating on a SIMATIC S7:
- Distributed safety at least version 5.4
- F System at least Version 6.1

The parameter data for the absolute encoder with PROFIsafe are described in a GSD file. This GSD file has been created separately and can only be applied for CRD/S3.

The CRD/S3 absolute encoder is a sensor for measuring the angular position of a rotating shaft and for determining the number of revolutions which have been carried out. Measurement of the angular speed also takes place.

The sensor scans a coding disk with the aid of a special opto chip as the dimensional embodiment of the angular position. Ascertainment of the number of revolutions which have been carried out is implemented via an electrically scanned, mechanical transmission.

The measured speed value is determined via the cyclically read-in position data. The dimension is digits per gating time. The speed measurement resolution is independent of the single turn resolution.

The following parameters can be programmed:

Code sense:	CW/CCW
Scaling:	Encoder programming via the bus can be activated or deactivated using a flag (scaling).
Resolution:	2 to 4096 (8192) steps per revolution
Total measuring steps:	2 to 16,777,216 (33,554,432) steps
Gating time:	Time intervall for the counting of steps for the speed measurement.

The following monitoring functions are implemented for safety-relevant use:

1. Monitoring of the controller function (memory test and CRC parameter test)
2. Programme sequence monitoring (implementation of inverse functions for the safety-critical programme functions).
3. Monitoring of the single turn position via movement detection in which impulses are generated from the position changes.
4. Monitoring of the revolution counter via parallel counting of the single turn zero transitions and comparison with multi-turn scanning.
5. Clock pulse and timer monitoring via a redundant clock pulse generator.
6. Functional monitoring of the FPGAs used to determine the position via a toggle bit which is triggered in the event of controller access.
7. Overvoltage and undervoltage monitoring.
8. Current monitoring for the position-determining light emitting diodes.
9. Supply current overcurrent protection.

In deviation from profile definition PNO 3.062, the encoder with Profisafe only has class 2 functionality. The definitions of the error statuses, which are displayed in the „Manufacturer-specific diagnosis“ diagnostic object, Octet 60-63, also deviate from the above mentioned profile

3. Specifications for meeting the safety standard

1. Observance of data sheet CRD12098 and the CRD12099 manual.
2. Maximum permissible rotational speed for applications with SIL2 classification 2500 rpm.
3. Use of an evaluation unit which supports the Profisafe protocol.
4. Evaluation of the F status and the encoder-specific diagnostic data.
5. Connection of a profibus cable in compliance with the standards /3/,/8/.

4. Installation instructions for PROFIsafe

4.1 Fundamental characteristics of the transmission technology (RS 485)

- Network topology: Linear bus, terminating resistors for bus termination
  Stub lines are only permissible with baud rates < 1.5 MBit/s
- Line: Shielded, twisted pair cable
- Number of stations: 32 stations in each segment without repeaters
  Can be extended to 126 with repeaters.

4.2 Wiring and bus termination for PROFIBUS-DP (note: 9-pin sub-D connector)

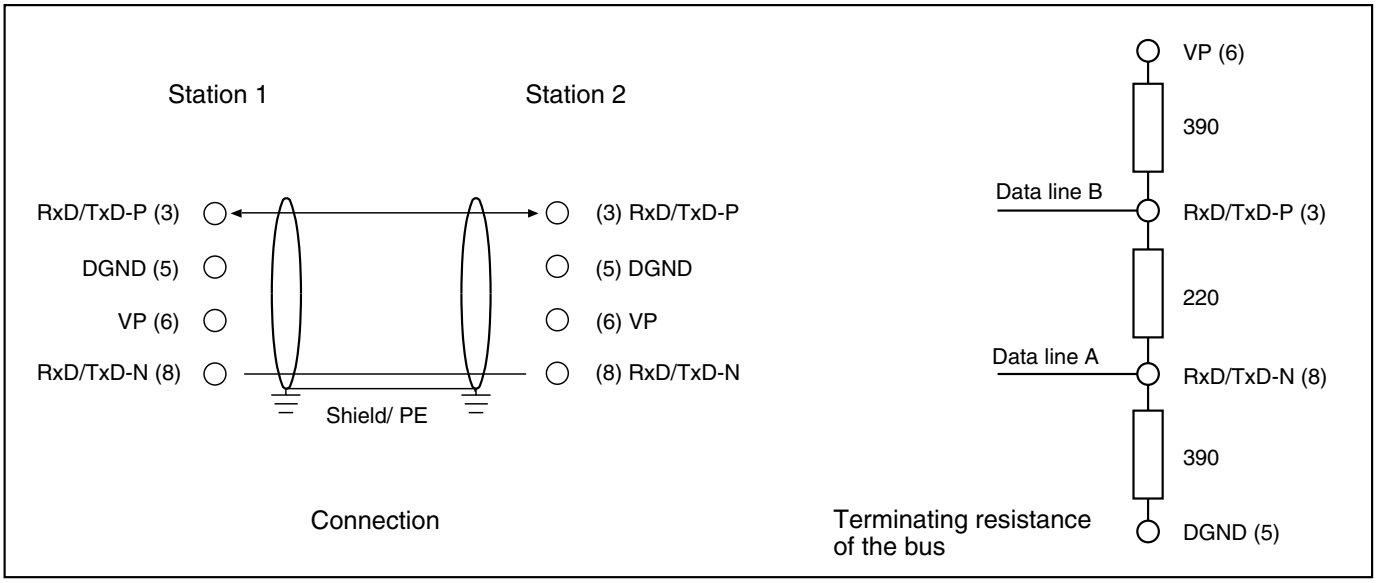


Figure 1

Transmission length depending on transmission speed for cable type A							
Baud rate [kBaud]	9.6	19.2	93.75	187.5	500	1500	12,000
Transmission length [m]	1200	1200	1200	1000	400	200	100

Cable type A specifications:

Characteristic impedance:	135...165 Ω
Capacitance per unit length coating:	< 30 pF/m
Loop resistance:	110 Ω/km
Core diameter:	0.64 mm
Core cross-section:	> 0.34 mm²

Also see: Installation Guideline for PROFIBUS -FMS/DP (Nr. 2.111/2.112 - PNO) /3/
and Profibus Installation Guideline (Nr. 8.021) /8/

4.3 Installation of the absolute encoder with connecting cap

The connecting cap for triple connection technology is a T coupler which is installed in the PROFIBUS. The connecting cap must be mounted on the absolute encoder in de-energised condition.

There are three cable glands, which are sub-divided as follows:

- M12x1.5: Voltage supply for the absolute encoder (24 VDC)
- M16x1.5: Bus in (receive/transmit data A,B)
- M16x1.5: Bus out (receive/transmit data A‘,B‘)

The absolute encoder is connected via the 15-pin SUB-D connector. In the event of an error, the encoder can be replaced without time-consuming installation. The connecting cap is disconnected from the absolute encoder by unscrewing 2 fastening screws. (Note: O-ring seal)

The station/subscriber address is set via the DIP switches in the connecting cap. The address range lies between 1 and 126 (default address: 123).

Attention! The profibus address in the connecting cap must correspond to the F parameter „F_Dest_Add“ (see Chapter 8.2)**.**

The terminating resistors are set via the 10-fold DIP switch (9,10) in the connecting cap; if necessary, these can be activated as line termination.

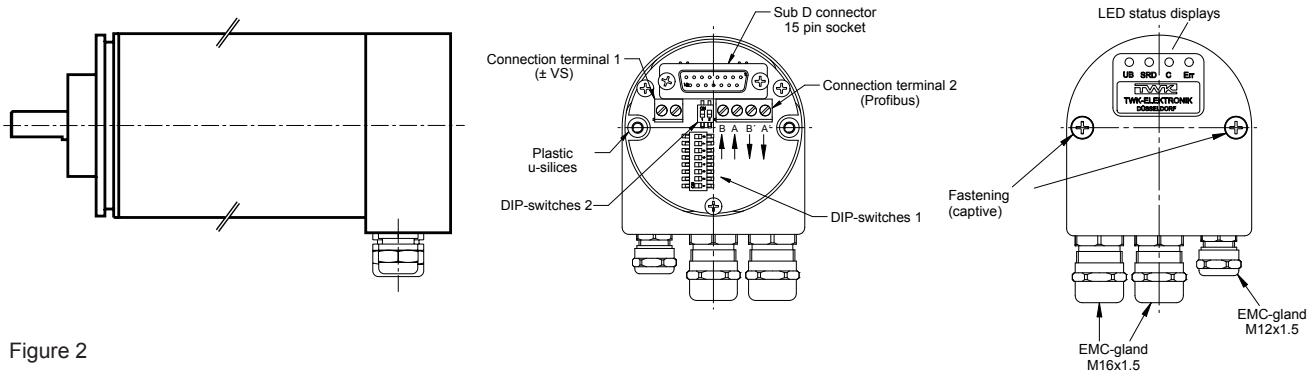
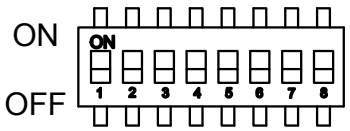


Figure 2

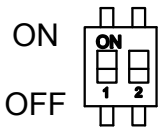
DIP switches - address setting/terminating resistors

	Dip-switches 1								Dip-switches 2	
Switch	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**
ON = 1	LSB						MSB	n.c.	Terminating resistors: On	
OFF = 0	Address can be set from 1- 126 (Default address: 123)								Terminating resistors: Off	

DIP-switches 1



DIP-switches 2



Status LEDs

UB - operating supply	**UB**
SRD - data transfer	**SRD**
C - class 2	**C**
Error message	**Err**

Description of error types chapter 5

5. Monitoring functions for safety-relevant use

The additionally implemented error types for achieving safety level SIL2 according to IEC 61508 are described in the following. For implementation purposes, extensive modifications have been carried out to the hardware and software in comparison with the basic CRD model absolute encoder with PROFIBUS interface.

Error output is carried out via the connecting cap's LEDs, via the profibus diagnostic data (standard and manufacturer-specific diagnosis) (see Chapter 9.2) and via the F status. The bits which are set in the profibus diagnostic data and in the F status are specified in the "Reaction" column.

5.1 Error type overview table

Error	Cause of error	Reaction	LEDs*			
			UB	SRD	C	Err
Position	Single turn array illumination faulty	EXT_Diag Flag = 1 Manufacturer Diag: PositionError F_Status: Device_Fault = 1 FV_activated = 1	on	off	off	on
	Impermissible difference between movement detection and position					
	Difference between multi-turn counter (software) and multi-turn scanning					
	Overvoltage at the supply input					
Speed	Impermissible difference between timer controller and external timer	EXT_Diag Flag = 1 Manufacturer Diag: SpeedError F_Status: Device_Fault = 1 FV_activated = 1	on	off	off	on
MSA	Toggle bit error FPGA	EXT_Diag Flag = 1 Manufacturer Diag: MSAError F_Status: Device_Fault = 1 FV_activated = 1	on	off	off	on
Parameter	Error in parameter message	EXT_Diag Flag = 1 Manufacturer Diag: ScalingError Diag.Prm_Fault = 1 Diag.Station_Not_Ready = 1	on	off	on	on
	Error in the standard parameters					
	Wrong standard parameter CRC-value					
F parameter	F parameter faulty	EXT_Diag Flag = 1 Manufacturer Diag: F-Parameter	on	off/ on	off/ on	on
Configuration	Master and slave configurations differ	Diag.Cfg_Fault = 1	on	on	off	on
Preset	Incorrect preset value	EXT_Diag Flag = 1 Manufacturer Diag: PresetError F_Status: FV_activated = 1				
Internal	Incorrect programme sequence	Stop controller	LED: Flashing code 1			
	CRC Error ROM	Stop controller	LED: Flashing code 2			
	RAM/XRAM Error	Stop controller	LED: Flashing code 3			
	Initialization sensor	Stop controller	LED: Flashing code 4			
	CRC EEPROM	Stop controller	LED: Flashing code 5			
	Error in the sensor, parameter access has failed	Stop controller	LED: Flashing code 6			
	Connecting cap expander error	Stop controller	LED: Flashing code 7			
*UB – operating voltage, SRD – data transfer, C - class 2, Err – error message						

5.2 Description of error types

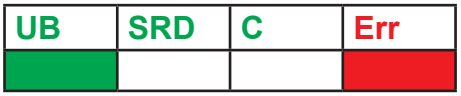
5.2.1 Position

The position and speed data cannot be used.
Causes:

- Single turn monitoring scanning error
- Error in the transmission diode unit
- Difference between multi-turn scanning and multi-turn counter
- FPGA error
- Overvoltage at the supply voltage input
- Rotational speed too high

Actions:

- Device_Fault = 1
- FV_activated = 1
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = position error (see Octet 63-66)
- Light emitting diodes: SRD off
  Class off
  Error on



Remedy:

- Reduce the rotational speed to below the maximum value specified in the data sheet.
- Check the supply voltage. This must lie within the limits specified in the data sheet.

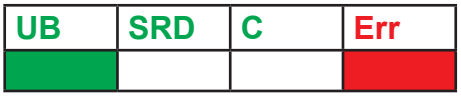
5.2.2 Speed

The position data are OK. Speed measurement is defective.
Causes:

- Impermissible difference between controller timer and external timer

Actions:

- Device_Fault = 1
- FV_activated = 1
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = speed error (see Octet 63-66)
- Light emitting diodes: SRD off
  Class off
  Error on



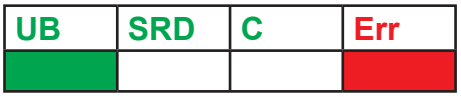
5.2.3 MSA

The position and speed data are presumably incorrect. The Multi-turn Single turn Array (MSA) is defective.
Causes:

- Toggle flag does not function correctly

Actions:

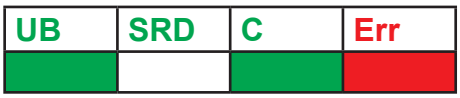
- Device_Fault = 1
- FV_activated = 1
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = MSA error (see Octet 63-66)
- Light emitting diodes: SRD off
  Class off
  Error on



5.2.4 Parameters

The encoder does not start up.
Causes:
- Error in standard parameter parameterisation or wrong standard parameter checksum

Actions:
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = scaling error (see Octet 63-66)
- Light emitting diodes: SRD off
  Class on
  Error on

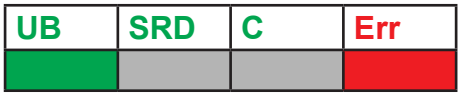


Remedy:
- Set permissible values for the standard parameters.

5.2.5 F parameters

The encoder achieves data exchange status if no further error is present.
Causes:
- The transferred F parameters are faulty

Actions:
- ExtDiag Flag = 1
- Light emitting diodes:: SRD off/on
  Class off/on
  Error on



- Manufacturer-specific diagnosis = F parameter error
  An error code is set in diagnosis octet 63. The following error codes are possible:

Hexa-decimal	Decimal	Error text
0x0040	64	Mismatch of safety destination address (F_Dest_Add)
0x0041	65	Safety destination address not valid (F_Dest_Add)
0x0042	66	Safety source address not valid (F_Source_Add)
0x0043	67	Safety watchdog time value is 0 ms (F_WD_Time)
0x0044	68	Parameter F_SIL exceeds SIL from specific device application
0x0045	69	Parameter F_CRC_Length does not match the generated values
0x0047	71	CRC1-Fault
0x0048	72	Device specific diagnosis information (Wrong F parameter version (F_PAR_VERSION) or wrong CRC length (F_CRC_ LENGTH)

Remedy:
- Set permissible values for the F parameters. A typical error is an incorrect slave address (F_Dest_Add)

5.2.6 Configuration

The encoder does not start up.
Causes:
- Difference between master configuration and slave configuration.

Actions:
- Light-emitting diodes: SRD on
  Class off
  Error on

UB	SRD	C	Err

Remedy:
- Transfer a correct configuration message (see Chapter 7)

5.2.7 Preset

The encoder is fully operable..
Causes:
- The preset value lies outside of the set total measuring steps
- The scaling flag in the operating mode byte is deactivated.

Actions:
- ExtDiag Flag = 1
- FV_activated = 1
- Manufacturer-specific diagnosis = preset value error (see Octet 63-66)
- Light emitting diodes: unchanged

Remedy:
- Transfer a pre-set value which lies between 0 and the total measuring steps -1.
- Before setting the pre-set value, the "scaling function" bit must be set to "enable". (see chapter 6.4)

5.2.8 Internal error

The micro-controller of the encoder stops all actions. A flashing code for the cause of the error is output.

LED: Flashing code	Error cause	Number of flashes (Period approx. 1 s)
Flashing code 1	Programme sequence error	1
Flashing code 2	CRC Error ROM	2
Flashing code 3	RAM/XRAM memory error	3
Flashing code 4	Sensor initialisation error	4
Flashing code 5	EEPROM memory error	5
Flashing code 6	Parameter access has failed	6
Flashing code 7	Connecting cap expander error	7

6. Data exchange function (DDLM_Data_Exchange)

Input data are data which are transmitted from the slave subscribers to the master (actual position value -> master). Reference value control (see below) is listed here as an example of output data; in this case, the master transmits data to the slave (absolute encoder).

6.1 Data format of I/O data

Input data: Slave to host

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7	Octet 8	Octet 9	Octet 10
MSB	Position Data		LSB	MSB Speed	LSB	F-Data			

Definition of F-Data can be found in /1/.

Output data: Host to slave

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7	Octet 8	Octet 9	Octet 10
MSB*	Preset Value		LSB	MSB Dummy	LSB	F-Data			

* Preset control via bit 31: 1/0

6.2 Positions data

The position value is output as a 32-bit unsigned integer value in Motorola format (Big-Endian).

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	25 Bit Position Data CRDxx-8192R4096S3Zxx																								
0	0	0	0	0	0	0	0	24 Bit Position Data CRDxx-4096R4096S3Zxx																							

6.3 Speed

The speed value is determined via the cyclically read-in of the position data. The dimension is steps per gating time. The gating time (time interval for determining the change of position) is adjustable in the range of 1 - 255 ms. The default value is 10 ms.

The speed measurement resolution is independent of the resolution set for the position value (resolution parameter). It is always based on a resolution of 4096 steps per revolution.

The steps/gating time unit can be converted to rpm as follows:

$$u = \frac{v \times 60000 / t}{4096}$$

v = encoder output for speed value
t = gating time in ms
u = speed in rpm

The speed value is output as a 16-bit signed integer value in Motorola format (Big-Endian). The following applies to the prefix:

positive for increasing position
negative for decreasing position

Octet 5								Octet 6							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Speed															

6.4 Set reference value (preset)

The set reference value function should only be carried out when the absolute encoder shaft is stationary!

In order to compare machine position values and the absolute position of the absolute encoder, setting the reference value is unavoidable in certain cases. The reference value is the position value which is displayed in the reference point. The user must note the fact that the reference value must lie within the range 0 to (total measuring steps - 1). In particular, this must be taken into consideration when changing the total measuring steps. The reference value is transferred in data exchange mode by setting bit 7/octet 1.

The reference value can only be set when scaling is activated (see Chapter 8.1)**!**

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0/1	0	0	0	0	0	0	25 Bit Preset Value CRDxx-8192R4096S3Zxx																								
0/1	0	0	0	0	0	0	0	24 Bit Preset Value CRDxx-4096R4096S3Zxx																							

Preset Control

After receiving this message, an offset value (from the current actual position value and the reference value) is calculated by the encoder. If the output actual position value is identical to the reference value, bit 31 can be reset by the master, as preset mode is terminated. The timing diagrams are specified in a separate TY sheet. After bit 31 has been reset, the absolute encoder operates in „normal operating mode“.

On inputting a faulty preset value, control bit 31 must be set to zero before inputting the correct preset value in order to rectify the error. After that the preset value can be set again by setting control bit 31 to 1.

7. Configuration (DDLM_Chk_Cfg)

Only Class 2 encoders are supported. Class 2 - devices are programmable via the Profibus (set reference value (preset)). The data format is: 10 byte input data and 10 byte output data. The configuration data is: 0xC8,0x89,0x89,0x03, 0x03,0x03,0xA,0x03,0x03,0x03,0x0A.

Configuration function (DDLM_Chk_Cfg)			
Selection	**Identifier byte**	**Data**	**Data format**
Class 2	0xC8,0x89,0x89,0x03,0x03,0x03, 0xA,0x03,0x03,0x03,0x0A	10 Byte Input data	**Encoder position** Octet 1/Bit 7: MSB Octet 4/Bit 0: LSB
			Velocity signal Octet 5/Bit 7: MSB Octet 6/ Bit 0: LSB
			F-Data Octet 7-Octet 10
		10 Byte Output data	**Preset value** Octet 1/Bit 7: Preset Control Octet 1/Bit 0: MSB Octet 4/ Bit 0: LSB
			Dummy Octet 5/Bit 7: MSB Octet 6/Bit 0: LSB
			F-Data Octet 7-Octet 10

8. Parameterisation (DDLM_Set_Prm)

The parameterisation data are sub-divided into standard parameters (bus-specific parameters, DP-V1 parameters and manufacturer-specific parameters) and the F parameters.

Octet 1-7	Standard parameters	Bus-specific parameters
Octet 8-10		DP-V1 parameters
Octet 11-31		Encoder-specific parameters
Octet 0-13	F parameters	

8.1 Standard parameters

8.1.1 Bus-specific parameters

Octet	Data type	Description	Default
1	BYTE	Station status	-
2	BYTE	WD_Fact_1	-
3	BYTE	WD_Fact_2	-
4	BYTE	Min. Station Delay Responder (min T_{SDR})	-
5/6	WORD	Ident_Number	0x1962
7	BYTE	Group_Ident	0

The definition of the bus-specific parameters can be found in /4/

8.1.2 DP-V1 parameters

Octet	Data type	Description	Default
8	BYTE	DPV1_Status_1	0x04
9	BYTE	DPV1_Status_2	0x00
10	BYTE	DPV1_Status_3	0x00

The DP-V1 mode is only supported in that way, that the parameter and diagnosis structure of DP-V1 is fulfilled. The DP-V1 functionality is not supported.

8.1.3 Encoder specific parameters

8.1.3.1 Overview

Octet	Data type	Description	Default
11	BYTE	Operating mode	0x08
12 - 15	LONG	Single turn resolution	4096 (8192)
16 - 19	LONG	Total measuring steps	16.777.216 (33.554.432)
20 - 27	STRING	Reserved for the profile	0
28	BYTE	Gating time	10
29	BYTE	Not used	0
30 - 31	WORD	Standard parameter CRC	0x14EC (0x151D)

The values in brackets represent the encoders with a total measuring range of 25 bit (CRDxx-8192R4096S3Zxx).

8.1.3.2 Description of encoder parameters

Octet No.	Bit No	Parameter	Range of values	Default	Description
11	0	Code sequence	0: clockwise (cw) 1: counter clock-wise (ccw)	clockwise (cw)	Ascending values on rotation clockwise (cw) or counter-clockwise (ccw). (Viewing direction towards the shaft)
	1-2	not used			
	3	Scaling function status	0: disabled 1: enabled	enabled	Must be set to "enabled" to change the reference value, resolution and total measuring steps.
	4-7	not used			
12 - 15		Singleturn resolution [steps/turn]	1 - 4096 (8192)	4096 (8192)	To change, the "scaling function status" parameter must be set to "enabled".
16 - 19		Total measuring steps	1 - 16.777.216 (33.554.432)	16.777.216 (33.554.432)	To change, the "scaling function status" parameter must be set to "enabled".
20 - 27		Reserved for the profile			
28		Gating time [ms]	1 - 255	10	Time interval for the counting of steps for the speed measurement
29		not used		0	
30 - 31		Standard parameter CRC	1 - 0xFFFF	0x14EC (0x151D)	CRC-checksumme for the standard parameters

Remarks:

Totals measuring steps:

It must be noted that the calculation of the number of revolutions is carried out in 2n powers internally within the encoder. Regardless of this requirement, the user may programme the desired total measuring steps and the desired resolution in accordance with the application. During calculation, the absolute encoder accesses the next highest 2n power if required. In this case, the values are designated as the actual resolution or as the actual total measuring steps, and are displayed as the output value.

Example:

Desired total measuring steps:	20,480
Desired resolution:	4096
Desired number of resolutions:	5 Internal absolute encoder calculation
Actual total measuring steps:	32,768
Actual resolution:	4096
Calculated number of revolutions:	8

(Note:The above mentioned note must be taken into consideration in the event of irreversible operation. In the example which is described, the position 0 is only achieved after 32,767 steps and not, as desired, after 20,479 steps.)

Standard parameter CRC:

The CRC checksum is build on the following parameters: operating mode, resolution, measuring range and gating time. The calculation is based on the CRC1 algorithm of the Profisafe specification with the polynomial generator 0x14EAB.

After changing one of the parameters, the checksum has to be recalculated and entered in the parameter "standard parameter CRC". The checksum calculation program PsCrc.exe is available for download on our homepage www.twk.de.

8.2 F parameters

8.2.1 Overview

Overview			
Octet	**Data type**	**Description**	**Default**
0	BYTE	Block-Length	0x0E
1	BYTE	Command = 0x05	0x05
2	BYTE	Slot	0
3	BYTE	Specifier	0
4	BYTE	F_Prm_Flag1	14 (für V1 Mode)
5	BYTE	F_Prm_Flag2	0
6-7	WORD	F_Source_Add	0
8-9	WORD	F_Dest_Add	123
10-11	WORD	F_WD_Time	2000
12-13	WORD	F_Par_CRC (=CRC1)	-

CRC1: checksum of F parameters
CRC2: checksum of processdata
CRC3: checksum of Individual parameters

8.2.2 Description of the F parameters

Octet 4: F_Prm_Flag1				
Bit No.	**Parameter name**	**Value range**	**Default**	**Remarks**
0	**F_Check_SeqNr**	0: NoCheck	NoCheck	
1	**F_Check_iPar**	0: NoCheck	NoCheck	
2-3	**F_SIL**	01b: SIL2	SIL2	
4-5	**F_CRC_Length**	00b: 3-Byte-CRC (V2 Mode) 01b: 2-Byte-CRC (V1 Mode) 10b: 4-Byte-CRC (optional V1/V2 Mode	2-Byte-CRC	Checksum of the process data (CRC2). Has to be set ot 3 byte CRC in V2 mode.
6-7	not used			

Octet 5: F_Prm_Flag2				
Bit No.	**Parameter name**	**Value range**	**Default**	**Remarks**
0-2	not used			
3-5	**F_Block_ID**	No F_iPar_CRC	No F_iPar_ CRC	
6-7	**F_Par_Version**	00b: V1-mode 01b: V2-mode 10b: 11b:	V1-mode	Parameter version

Octet 6-13				
Octet	**Parameter name**	**Value range**	**Default**	**Remarks**
6-7	**F_Source_Add**	1 - 65534		Automatically assigned by the SIMATIC manager
8-9	**F_Dest_Add**	1 - 123	123	Must correspond to the address set in the connecting cap (DIP switches)!
10-11	**F_WD_Time**	1 - 65534	2000	Monitoring time in the failsafe DP standard slave. Within the monitoring time, a valid, current safety message must be received from the F CPU.
12-13	**F_ParCRC (CRC1)**	0 - 65535		CRC checksum on the F parameters

9. Diagnostic messages (DDLM_Slave_Diag)

9.1 Diagnostic overview

Diagnostic messages DDLM_Slave_Diag				
Diagnostic octet number	**Diagnostic function**	**Octet**	**Default**	**Remark**
1-6	Standard diagnostic information	01	00hex	
		02	0Chex	Response monitoring activate, bit 2 firmly to 1
		03	00hex	
		04	01hex	Parameterisation via master with address 1
		05-06	1962hex	ID number CRD
Device-related diagnosis				
7	Extended header byte	3Chex		60 diagnostic bytes
8	Status type	81hex		Status block / status message
9	Slot number	00hex		
10	Status specifier	00hex		
11	Alarm messages	00hex		Not supported
12	Operating parameters	08hex		CW, scaling on
13	Encoder type	01hex		Absolute multi-turn encoder
14(MSB)-17(LSB)	Resolution	0000.1000hex (0000.2000hex)		4096 (8192) steps/ revolutions
18-19	Measuring range	1000hex		4096 revolutions
20	Additional alarm messages	00hex		None
21-22	Supported alarm messages	0000hex		None
23-24	Warning messages	0000hex		Not supported
25-26	Supported warning messages	0000hex		Not supported
27-28	Profile version	0x0101		
29-30	Software version	xx.xx		
31-34	Operating time	FFFF.FFFFhex		Not supported
35-38	Offset value	0000.0000hex		
39-42	Manufacturer offset value	0000.0000hex		
43 (MSB) - 46 (LSB)	Resolution	0000.1000hex (0000.2000hex)		Equal with parameter
47(MSB) - 50 (LSB)	Total measuring steps	01.000.000hex (02.000.000hex)		Equal with parameter
51-60	Serial number	2A2A2A2A2A 2A2A2A2A2Ahex		Not supported
61-62	Reserved	0000hex		
63-66	Manufacturer-specific diagnosis	00000000hex		Defined during run time

The values in brackets represent the encoders with a total measuring range of 25 bit (CRDxx-8192R4096S3Zxx).

9.2 Diagnostic description

Explanations regarding the diagnostic information:

9.2.1 Standard diagnostic information (Octet 1-6)

For a detailed description, see IEC 61158 Type 3 and IEC 61784, PROFIBUS DP Specification /4/ (Note: Octet 5,6: Manufacturer identification: 1962hex)

The manufacturer identification is stored in the PNO and identifies the subscriber as a TWK absolute encoder.

9.2.2 Extended header byte (Octet 7)

The length of the extended diagnostic bytes including the header is specified in the diagnostic header (Octet 7).

(Profisafe encoder CRD/S3: 3Chex = 60d

-> 6 (Standard diagnosis) + 60 (Encoder diagnosis) = 66 Diagnosis bytes)

9.2.3 Alarm or status type (Octet 8)

This byte is firmly set to 0x81 and specifies that the diagnostic telegram is a status message.

9.2.4 Slot number (Octet 9)

This byte is firmly set to 0x00, because the encoder has no slots.

9.2.5 Status specifier (Octet 10)

This byte is firmly set to 0x00, that means there is no further differentiation of the statusmessages.

9.2.6 Alarm messages (Octet 11)

No alarm messages are output here. All error messages are output in the manufacturer-specific diagnostic range (octets 63-66)

9.2.7 Operating status (Octet 12)

Mirroring of the parameter operating mode.

9.2.8 Encoder Typ (Octet 13)

The byte is set firmly to 0x01, i.e. "absolute multiturn encoder"

9.2.9 Resolution (Octet 14-17)

Maximum value for the parameter resolution.

Parameter	Resolution			
Diagnosis Octet	14	15	16	17
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.10 Measuring range (Octet 18,19)

The maximum possible number of revolutions, specified via the resolution of the multi-turn section. Depiction in hexa-decimal form, e.g. 4096 revolutions = 1000hex.

Parameter	Measuring range	
Diagnosis Octet	18	19
Definition	MSB 15-8	7-0 LSB

9.2.11 Additional alarm messages (Octet 20)

Not currently assigned..

9.2.12 Supported alarm messages (Octet 21,22)

No alarm messages supported.

9.2.13 Warning messages (Octet 23,24)

These functions are not supported at present.

9.2.14 Supported warnings (Octet 25,26)

These functions are not supported at present.

9.2.15 Profile version (Octet 27,28)

Parameter	Profile version	
Diagnosis Octet	27	28
Definition	Revision number	Index

Current encoder profile version: 1.1.

9.2.16 Software version (Octet 29,30)

Parameter	Software version	
Diagnosis Octet	29	30
Definition	Revision number	Index

Current software version: 3.04

9.2.17 Operating time (Octet 31-34)

This function is not supported at present. The operating time is set to FFFF FFFFhex as default according to the encoder profile.

9.2.18 Offset value (Octet 35-38)

The offset value is the value for the shift in the zero point after setting the preset value.

Parameter	Offset value			
Diagnosis Octet	35	36	37	38
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.19 Manufacturer offset value (Octet 39-42)

Not supported at present.

9.2.20 Resolution (Octet 43-46)

The resolution set by parametration.

Parameter	Resolution			
Diagnosis Octet	43	44	45	46
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.21 Total measuring steps (Octet 47-50)

Set total measuring steps incremented to the next highest power of two. In this regard, also see the note under chapter 8.1.3.2.

Parameter	Total measuring steps			
Diagnosis Octet	47	48	49	50
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.22 Serial number (Octet 51-60)

This parameter is not supported at present.

9.2.23 Octet 61,62

Reserved

9.2.24 Manufacturer-specific diagnosis (Octet 63-66)

Overview

Manufacturerspecific diagnosis octet No.	Bit	Error
63	0-7	F parameter
64	not uses	
65	not used	
66	0	Scaling
	1	Preset value
	2	Position
	3	Speed
	4	MSA
	5-7	Not supported

A detailed description of the errors can be found in chapter 5.

10. Simatic Step7 with Distributed Safety

This chapter explains the procedure for integrating the TWK absolute encoder into the profibus of a Siemens S7 control system. The documentation is based on Step 7 with distributed safety version 5.4.

10.1 Integration of the TWK profibus absolute encoder

Prerequisites:

- You have configured your hardware in accordance with the structure of your control system and have installed a profibus sub-network.
- You have set the check mark for "CPU contains safety program" in the properties of your CPU and have secured the access to the F-CPU by a password.

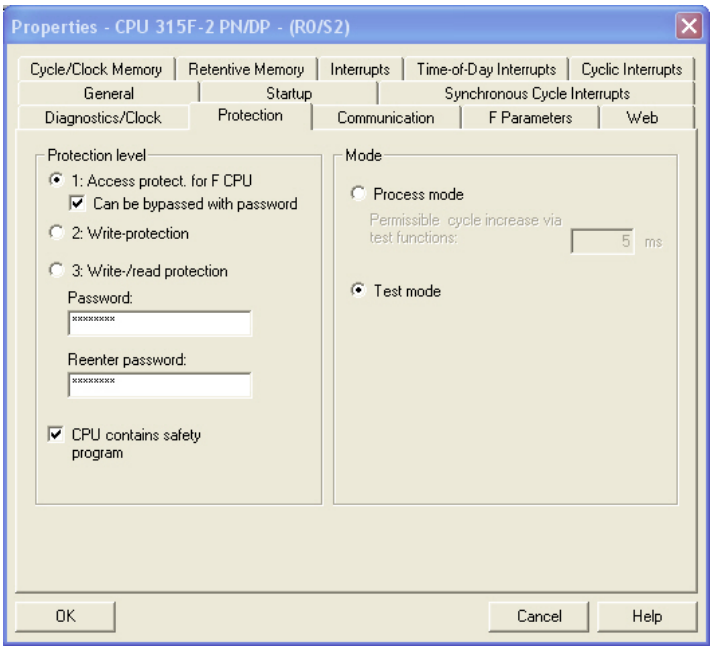


Figure 3

10.1.1 Installation of the GSD file

- Close all projects in the hardware configuration.
- In the hardware configuration, select Install GSD files under Options.
- Choose "from the directory", browse to the GSD file **CS3_1962.GSD** (see figure 4) and click on "Install".
- If the bitmap is located in the same directory as the GSD-file it is installed automatically,

Remark: The GSD-file and the bitmap are available for download on our homepage www.twk.de.

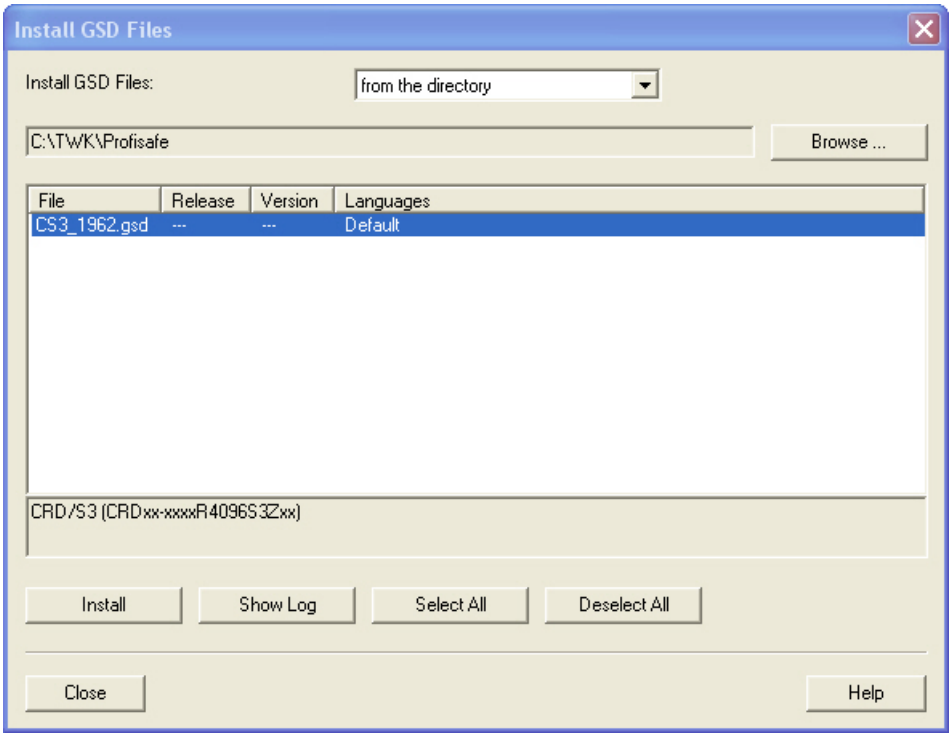


Figure 4

10.1.2 Selection of the TWK absolute encoder from the Step7 hardware catalogue

- After opening the hardware catalogue, you will find the encoder **CRD/S3** under **Profibus-DP, Additional Field Devices, Encoders**.
- Now open your project, mark the bus and integrate the absolute encoder into the bus by double-clicking onto the corresponding line of the hardware catalogue.

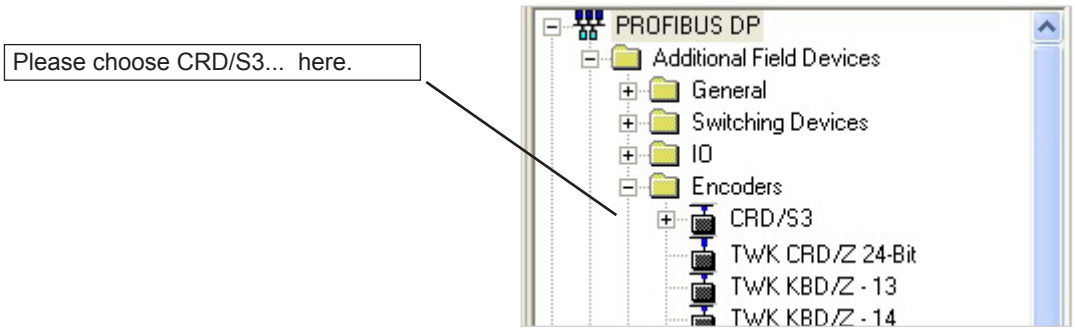


Figure 5

- Afterwars the dialog for setting the Profibus address will appear.

10.1.3 Setting of the profibus address

Please specify the address set in the connecting cap via the DIP switches here.

In the Subnet field, additionally select your planned profibus and exit the window with OK.

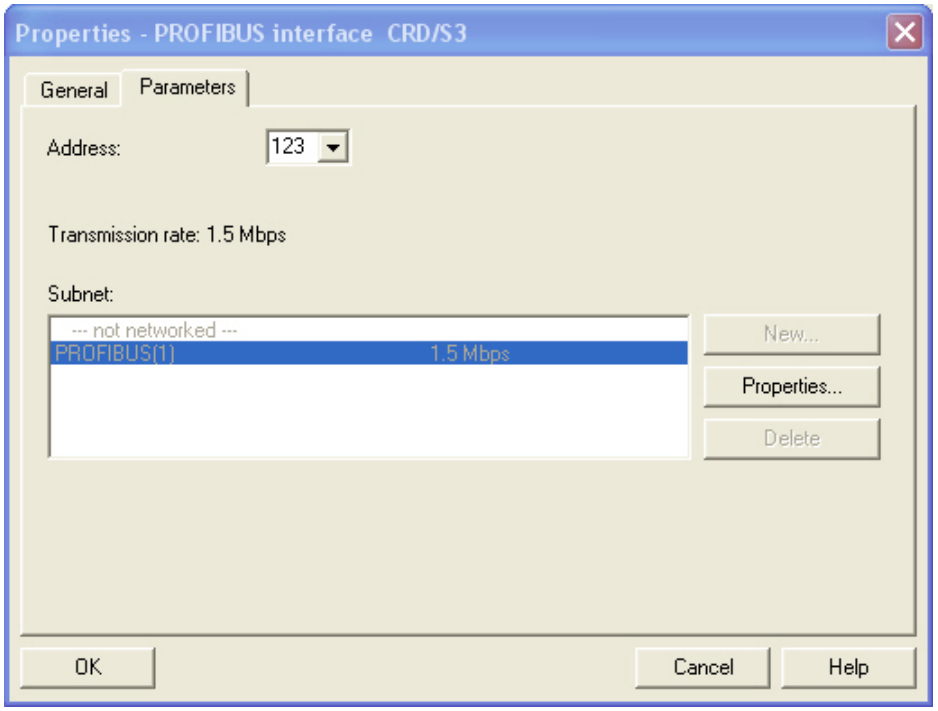


Figure 6

10.1.4 Install modul

Than drag the corresponding modul (see article number on the label) on slot 1 of the modul list.

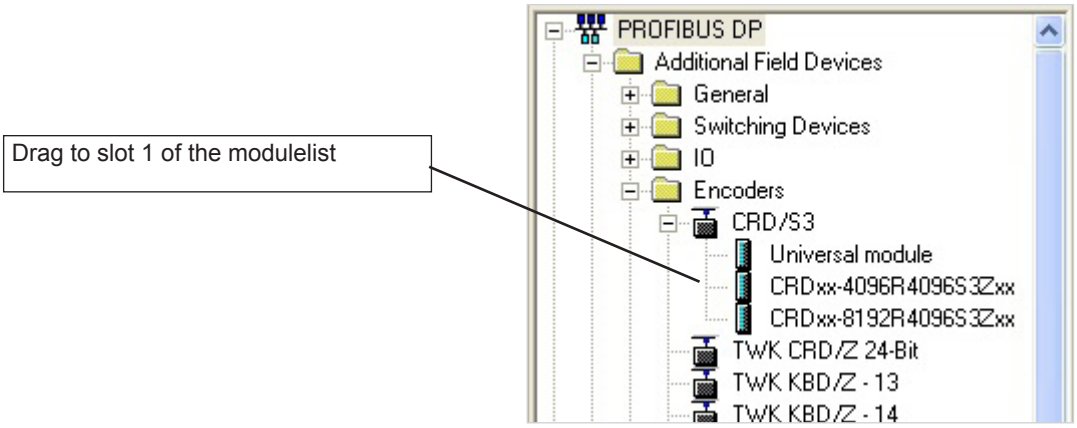


Figure 7

The absolute encoder should then appear as follows in your project planning:

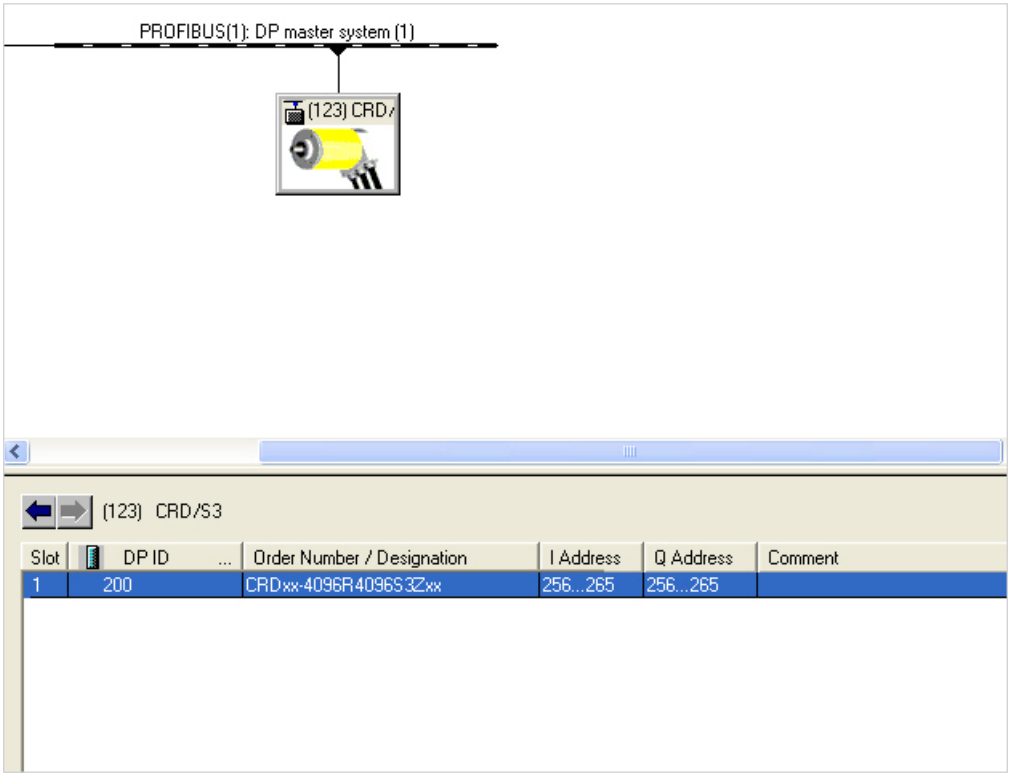


Figure 8

The **DP ID** value results from the configuration, which is firmly set in the case of the Profisafe absolute encoder. The I/O address values are default values, which vary depending on the control system.

10.1.5 Setting the I/O addresses (S7 addresses)

Double-clicking onto the „Slot 1“ line opens up the Properties – DP slave window with the Address / ID, Parameter Assignment and PROFIsafe registers. The addresses for the absolute encoder, under which this is to be addressed in the S7, must be assigned under output and input in the Address / ID register.

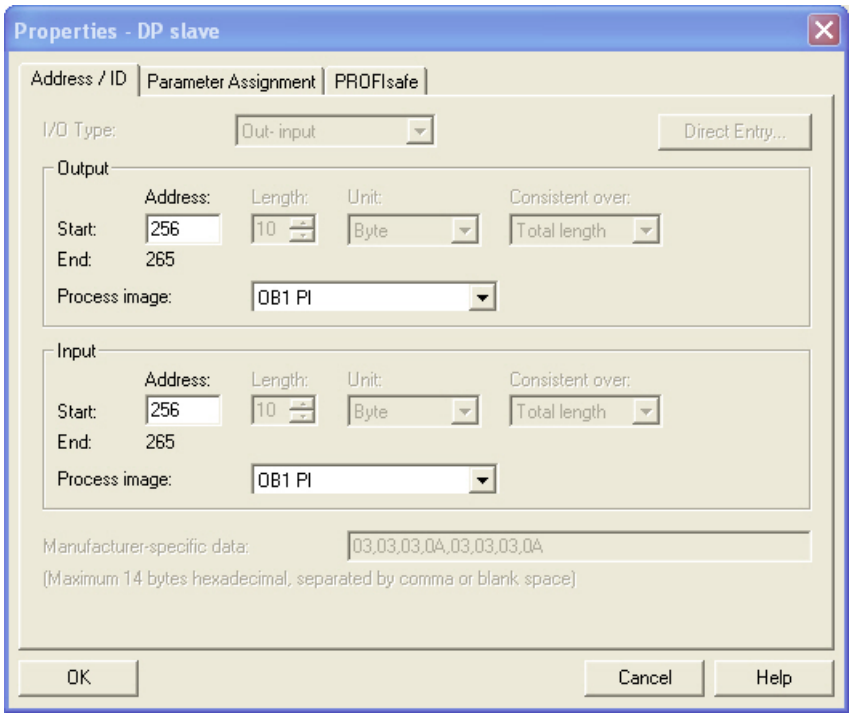


Figure 9

10.1.6 Parameterisation of the absolute encoder

Via the Parameter Assignment register, the following window, in which the characteristics of the absolute encoder can be defined, is accessed. (see chapter 8.1.3)

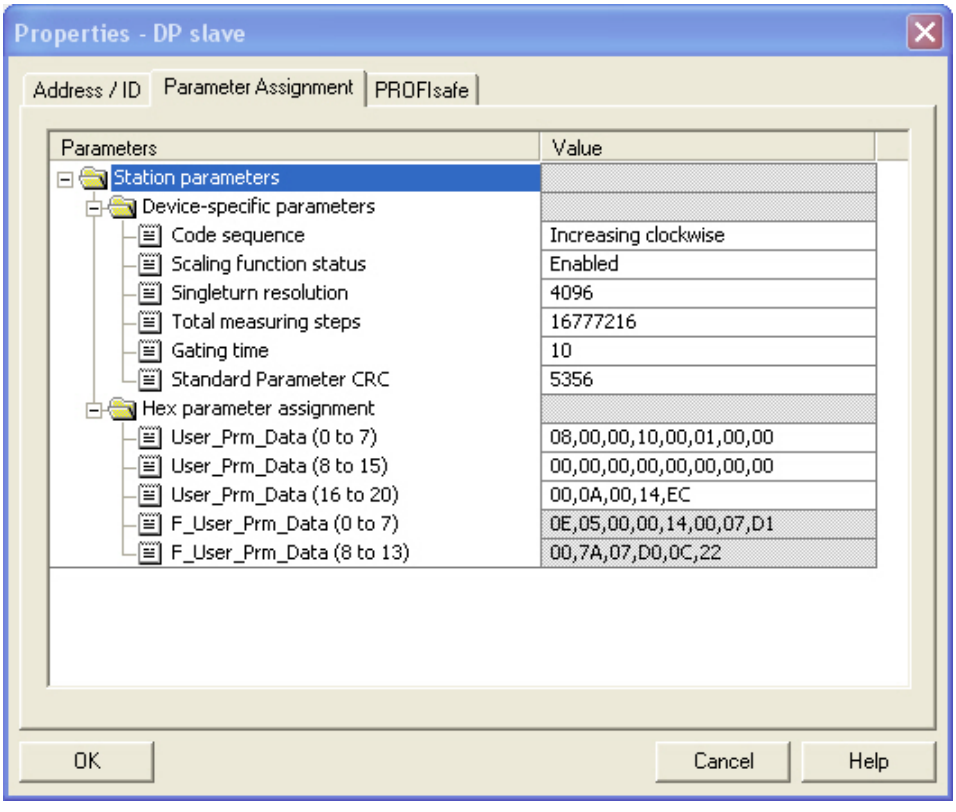


Figure 10

10.1.7 Setting the F paramters

Via the PROFIsafe register, the following window, in which the F parameters can be defined, is accessed (see Chapter 8.2)

Note: Under certain circumstances, Step7 may show a different default value for F_Dest_Add here. This must be set to the set profibus address!

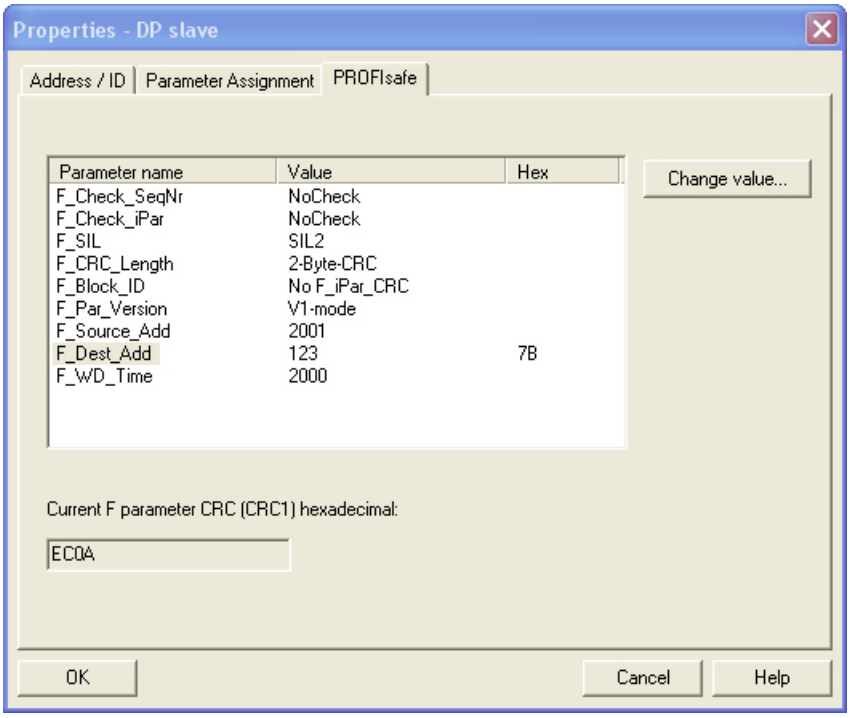


Figure 11

10.1.8 Setting the diagnostic address

So that the absolute encoder‘s diagnostic area can be accessed within the S7 programme, it is necessary to assign a specific S7 diagnostic address to it. This may lie within the entire periphery area of the control system. It does not therefore occupy any input/output addresses.

The **Properties – DP slave** window with the **General** and **Parameter Assignment** register appears by double-clicking onto the encoder symbol. On the register General you can now set the diagnostic address and confirm it with OK.

No further settings can be done on the register **Parameter Assignment.**

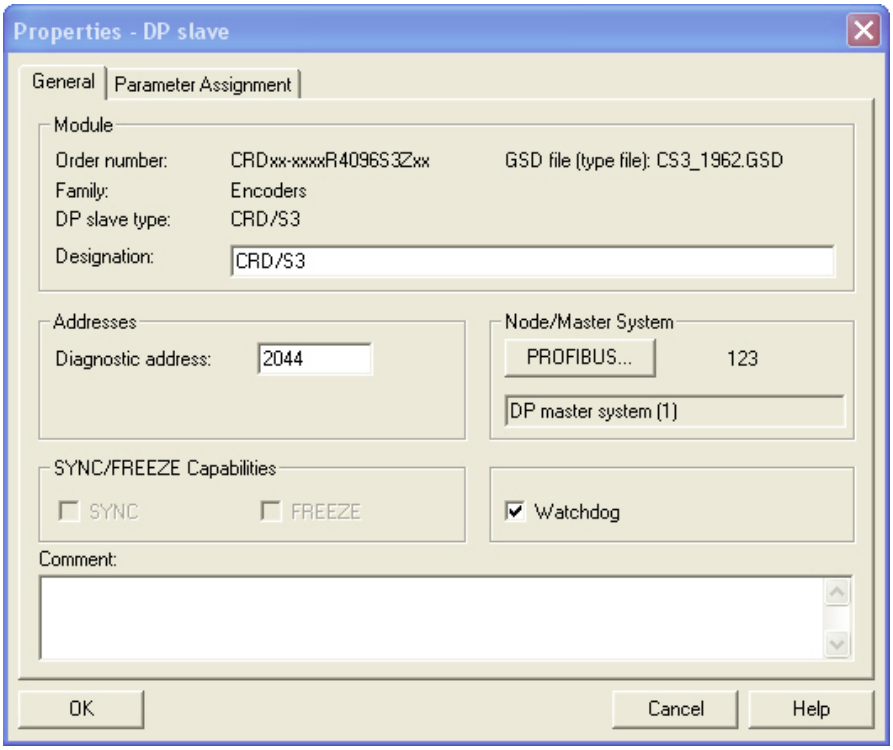


Figure 12

10.2 General notes regarding the PROFIsafe program

Due to the very complex scope for F programme project planning and programming, reference must be made to the documentation from Siemens at this point.

SIMATIC S7 Distributed Safety – Project Planning and Programming, Programming and Operating Manual (A5E00109536-03) /6/ and SIMATIC S7 Distributed Safety Getting Started /7/.

The sequences required for the PROFIsafe application are listed briefly in the following.

10.2.1 F-Peripherie-DB

On translation of the hardware configuration, an **F periphery DB** is generated for the absolulute encoder, as for each other Profisafe subscriber. The automatically generated name consists of the I/O address and the DP ID.

The F periphery DB contains the for the operation of the encoder necessary variables. It has the following appearance: (A detailed description can be found under /6/)

Address	Declaration	Name	Type	Initial value	Comment
0.0	in	PASS_ON	BOOL	FALSE	1=ACTIVATE PASSIVATION
0.1	in	ACK_NEC	BOOL	TRUE	1=ACKNOWLEDGEMENT NECESSARY
0.2	in	ACK_REI	BOOL	FALSE	1=ACKNOWLEDGEMENT FOR REINTEGRATION
0.3	in	IPAR_EN	BOOL	FALSE	1=ENABLE I-PARAMETER ASSIGNMENT
2.0	out	PASS_OUT	BOOL	TRUE	1=PASSIVATION OUTPUT
2.1	out	QBAD	BOOL	TRUE	1=FAIL-SAFE VALUES ARE OUTPUT
2.2	out	ACK_REQ	BOOL	FALSE	1=ACKNOWLEDGEMENT REQUEST
2.3	out	IPAR_OK	BOOL	FALSE	1=NEW I-PARAMETER VALUES ASSIGNED
3.0	out	DIAG	BYTE	B#16#0	DIAGNOSTIC INFORMATION
4.0	out	QBAD_I_00	BOOL	TRUE	1=FAIL-SAFE VALUE IS OUTPUT AT INPUT CHANNEL 0

Figure 13

10.2.2 Processing the F sequence module

To facilitate handling, a safety programme consists of F sequence modules.

These consist of:

- An F call module F CALL
- An F programme module F-PB (this is an F-FB/F-FC, which you assign to the F CALL)
- Poss. further F-FBs/F-FCs
- One or more F-DBs
- F periphery DBs
- F library F modules
- F system modules (F-SBs)
- Automatically generated F modules

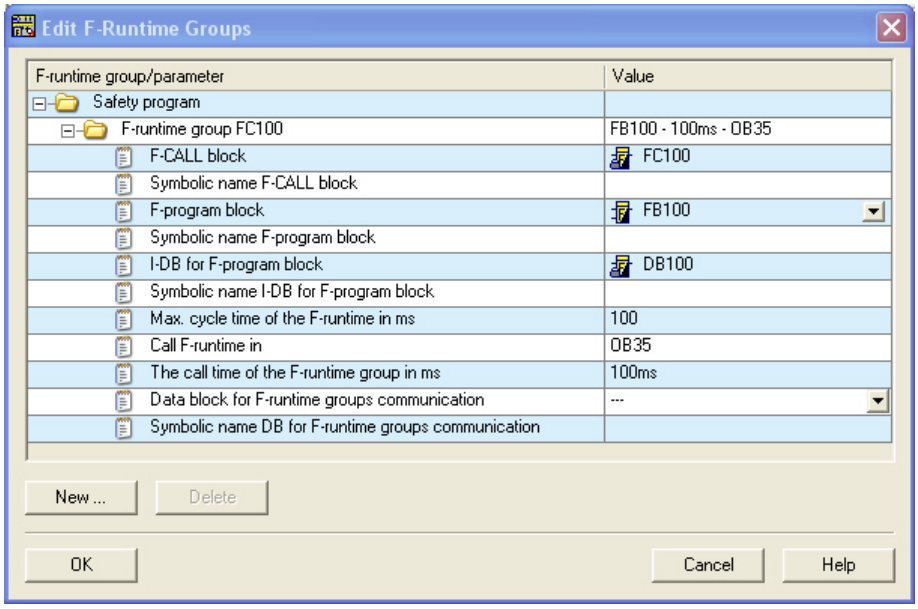


Figure 14

10.2.3 PROFIsafe OB 35

The safety programme is acessed by calling F CALL; this takes place directly in an OB, e.g. OB 35. In a wake-up alarm OB, the safety programme is called up and run through at fixed intervals of time.

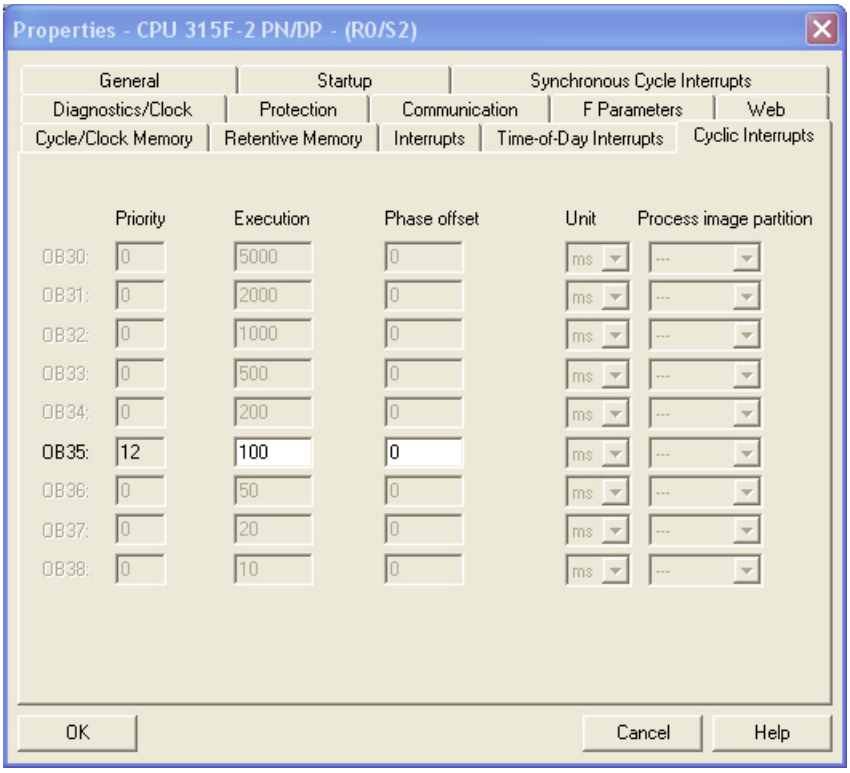


Figure 15

10.2.4 Accessing the encoder in the F program

Important for the fail safe operation of the encoder are: reintegration after communication or F periphery errors by the variables „ACK_REQ“ and "ACK_REI", evaluation of the failsafe status by the variable "QBAD" and the evaluation of the diagnostic data by the variable "DIAG". All mentioned variables are provided by the F periphery DB. An example can be found in chapter 10.3.

The access to the I/O data of the encoder (position, speed and preset) is only allowed in the safety program (F-FB or F-FC).

Because the use of double words in the safety program is prohibited, only word access to the 32 bit position and reference value is possible, that means the position and the reference value are devided into 2 words each and the evalutation has to be done seperately.

10.3 Example program

The following example shows how to access the position value and the F periphery DB of the Profisafe absolute encoder in the safety programme. Setting a preset value is also demonstrated.

An example for the reading of the encoders diagnostic data can be found in the supplement CRD 12532. The procedure ist the same as under Profibus and is done in the standard program part.

Only the programming steps which refer to the TWK absolute encoder are shown here. Knowledge regarding the programming and sequence of the failsafe S7 programme is assumed. As an introduction to failsafe programming, we recommend „SIMATIC S7 Distributed Safety - Getting Started“ /7/ and „SIMATIC S7 Distributed Safety – Project Planning and Programming“ /6/.

The OB1 and FB100 modules are available for download on our homepage www.twk.de as archive file „TwkBspSE.zip“. The password for the FB100 is „twk“.

Note: TWK-ELEKTRONIK GmbH does not undertake to provide any guarantee for the error-free function of the example programmes shown here!

Devices required to operate the example programme

- F CPU with profibus interface
- Standard input assembly
- Standard output assembly
- Profisafe CRD absolute encoder
- Step7 as of V5.4 + S7 distributed safety as of version V5.4

Hardware structure of the example programme

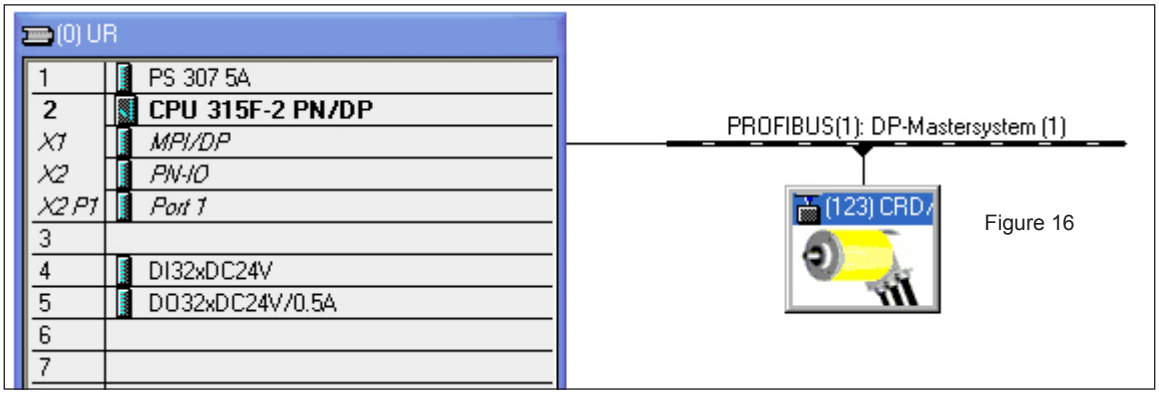


Figure 16

Assigned I/O addresses:

Input assembly DI32	Bytes 0...4
Output assembly DO32	Bytes 4...7
Absolute encoder	Bytes 100...109

Inputs and outputs used in the programme:

E 0.0	Acknowledgement for reintegration
E 0.1	Set preset
EW 100	High word of the encoder position value
EW 102	Low word of the encoder position value
EW 104	Speed value
A 4.0	„Acknowledgement required“ display
A 5.0	Failsafe status display
A 5.6	Display of the threshold value monitoring 1
A 5.7	Display of the threshold value monitoring 2
AW 100	High word of the encoder preset value
AW 102	Low word of the encoder preset value

Programming

Access to the profisafe absolute encoder is carried out in an F programme module (here FB100), which must be called up in an F call-up module F CALL. Calling the FB100 in the F CALL is not described here.

The preset value and preset bit compilation is contained in a standard module (here OB1). This is carried out here under the prerequisite that setting the preset is not a safety-relevant function.The decision regarding whether setting the preset value is a safety-relevant function must be made depending on the application.

The networks 9 and 10 contain examples for a threshold value monitoring. Remark; The position value consists of two words. The compare operation needs integer values. The examples show how to carry out the comparision between the position and the threshold values.

The following listing contains only the for the handling of the encoder relevant part. Program blocks like F-CALL, clock OBs or peripheral data blocks are not listed. The non-secure signals in the safety programme (FB100 in this case) are shown in red.

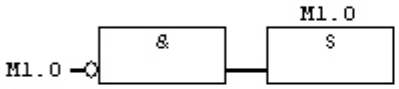
OB 1 : Load preset value and interpretation variable DIAG

OB1 : "Main Program Sweep (Cycle)"

The preset value is stored in the MD100. This is then read word-by-word in the safety programme (FB100). The safety programme is called by the FC100.

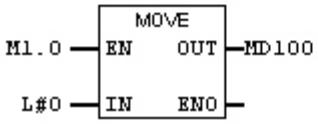
Network 1: Title:

Generate one flag



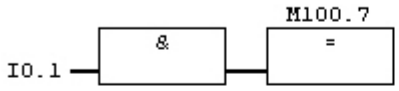
Network 2 : Title:

Write preset value (here 0) to double flag word.



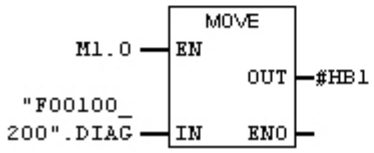
Network 3 : Title:

Set preset bit (highest-value bit in the double flag word) via a push button input



Network 4 : Title:

Display of F error messages (here in help byte 1; in a real system, this should be further processed in the error message system). Polling the DIAG variable in the safety programme is not permissible.
(Meaning of the individual bits in /6/)



FB 100, NW 1 - 4: Reset, interpretation QBAD and set preset value

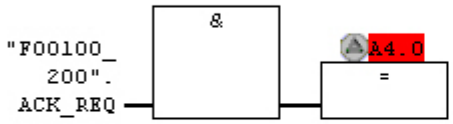
	Name	Data Type	Address	Initial Val	Exclusion address	Term
	HM1	Bool	0.0	FALSE	☐	
	HW1	Int	2.0	0	☐	
	HW2	Int	4.0	0	☐	
	HW3	Int	6.0	0	☐	
					☐	

FB100 : TWK CRD absolute encoder with SIL2 as a PROFISAFE subscriber

Acknowledgement, set preset and read out actual value

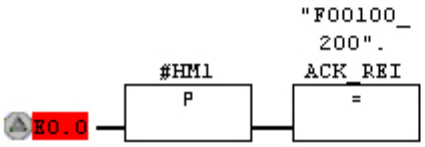
Netzwerk 1 : Titel:

Display necessary user acknowledgement



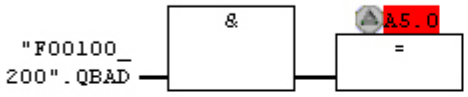
Netzwerk 2 : 1=ACKNOWLEDGEMENT FOR REINTEGRATION

Carry out user acknowledgement



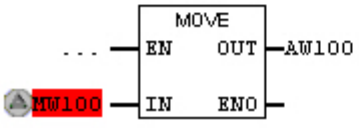
Netzwerk 3 : Titel:

Polling of the failsafe status of the absolute encoder (Here displayed at Output
5.0). In a real system this bit must be polled to introduce the fail safe state of the system. In case of QBAD = 1 the system has to go in the fail safe state.



Netzwerk 4 : Titel:

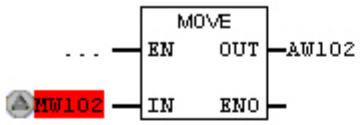
Write higher-value preset value from OB1 to higher-value output word
(Only word-by-word access is permitted in the safety programme)



FB 100, NW 5 - 8: Set preset value and read actual values

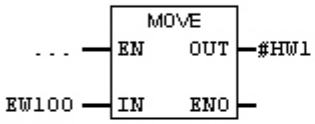
Netzwerk 5 : Titel:

```
Write lower-value preset value from OB1 to lower-value output word
```



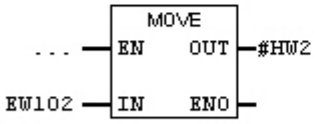
Netzwerk 6 : Titel:

```
Display of the higher-value actual position value
(Only word-by-word access is permitted in the safety programme)
```



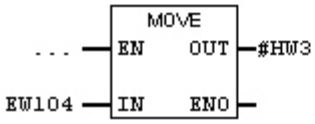
Netzwerk 7 : Titel:

```
Display of the lower-value actual position value
```



Netzwerk 8 : Titel:

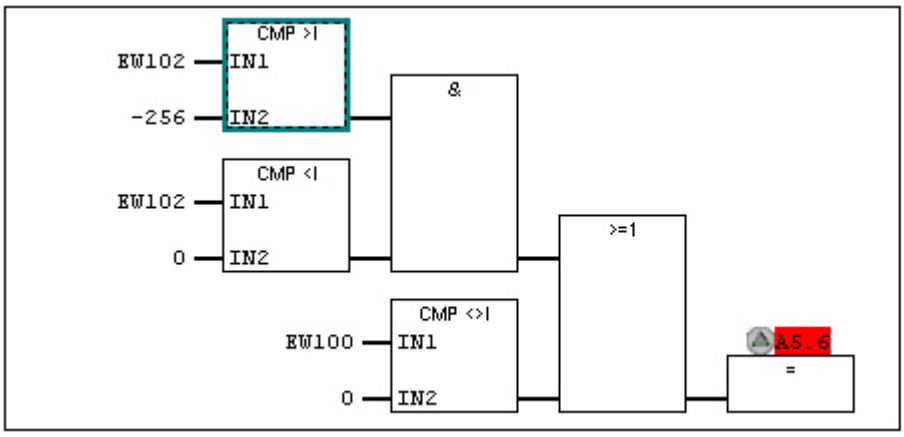
```
Display of the speed value
```



FB 100, NW 9 - 10: Threshold value monitoring

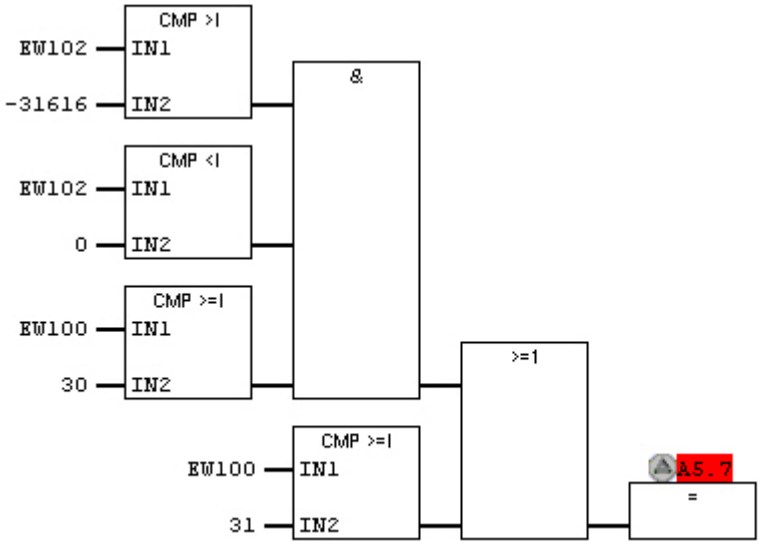
Netzwerk 9: Treshold comparison

```
Example 1:
Comparison: position value > 65280 (0xff00).
The comparison position value > 65280 in word format is equivalent to -256 <
position value < 0 in integer format.
(Values from 0,...,65536 in word format are equivalent to
0,...,32767,-32768,...,-1 in int format)
On carry over to the high word the output will be held to one by the third
comparison.
The result is shown on a non safety output here. In a real system it has to be
used in the safety program according the safety application.
```



Netzwerk 10 : Treshold comparison

```
Example 2:
Comparison: position value > 2000000 (0x1E8480).
The comparison position value > 2000000 in word format is in interger format
equivalent to -31616 < position value < 0 for the low word and position value
>= 30 for the high word.
On the next carry over to the high word, the output will be held to one by the
fourth comparison.
The result is shown on a non safety output here. In a real system it has to be
used in the safety program according the safety application.
```



11. Scope of delivery

The scope of delivery includes:
- Absolute encoder with PROFIsafe interface
- Pin assignment TY XXXXX (depending on the device variant)

Available for download on our homepage www.twk.de are:
- the corresponding datasheet
- this manual
- PNO and TÜV certificates
- example programs
- bitmap and GSD-file
- the CRC checksum calculation program

12. Literature

/1/ PROFIsafe Profile for Safety Technology, Order No. 3.092, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
PROFIsafe Profile for Safety Technology, Order No. 3.192, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/2/ PROFIBUS Profile for Encoders, Order No. 3.062, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/3/ Installation Guideline for PROFIBUS DP/FMS, Order No. 2111/ 2.112, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/4/ IEC 61158 Type 3 and IEC 61784, PROFIBUS DP Specification

/5/ PROFIsafe - Environmental Requirements related to PROFIsafe - Profile for Safety Technology on PROFI BUS DP and PROFINET IO (IEC 61784-3-3), Order No. 2.232, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/6/ SIMATIC S7 Distributed Safety – Project Planning and Programming, Programming and Operating Manual (A5 E00109536-03)

/7/ SIMATIC S7 Distributed Safety Getting Started (A5E00320725-01)

/8/ Profibus Installation Guideline, Order No. 8.021, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

Appendix A: Absoute encoder terms

Parameter	Explanation
Resolution – steps/360°	The resolution specifies the number of steps per revolution (360°).
Measuring range	The measuring range specifies the maximum number of revolutions. The revolutions must be specified in 2n powers.
Total measuring steps	The total measuring steps arise as follows: Total measuring steps = resolution x measuring range
Code sequence	The code sequence specifies the direction of rotation in which the encoder‘s output code corresponds to ascending values. A distinction is made between the following depending on the direction of rotation: CW - clockwise, clockwise direction of rotation CCW - counter clockwise, anti-clockwise direction of rotation (viewed in the direction of the shaft)
Reference value	The reference value is the value which appears after the preset function as the encoder‘s actual position value. It lies in the range of values from 0 to total measuring steps -1.